Advanced Docking Mechanism

Alan J. Bean/EP43
205–544–9401
E-mail: alan.j.bean@msfc.nasa.gov

Docking technology began with the development of the Gemini and Apollo docking systems by the United States, and the successful probe and drogue series of docking systems by the Soviet Union. These early systems laid the groundwork for the development of the Apollo-Soyuz docking system from which the current manned spacecraft docking hardware is derived, the U.S. Space Station Phase B docking/berthing system and the Russian automated payload attach system (APAS). Both U.S. and Russian docking experts have recognized a new approach, termed capture-berthing, as a leading candidate for the next generation of spacecraft mating hardware. Traditionally, docking systems rely on the loads generated by contact of the two mating spacecraft to enable the docking process. This leads to potentially high loads in the spacecraft being mated. Capture-berthing, however, is a process by which one spacecraft “reaches out,” attaches to, and mates with the other spacecraft after the two spacecraft are station-keeping within close proximity of each other. This process greatly reduces the potential loads which could be generated in both spacecraft.

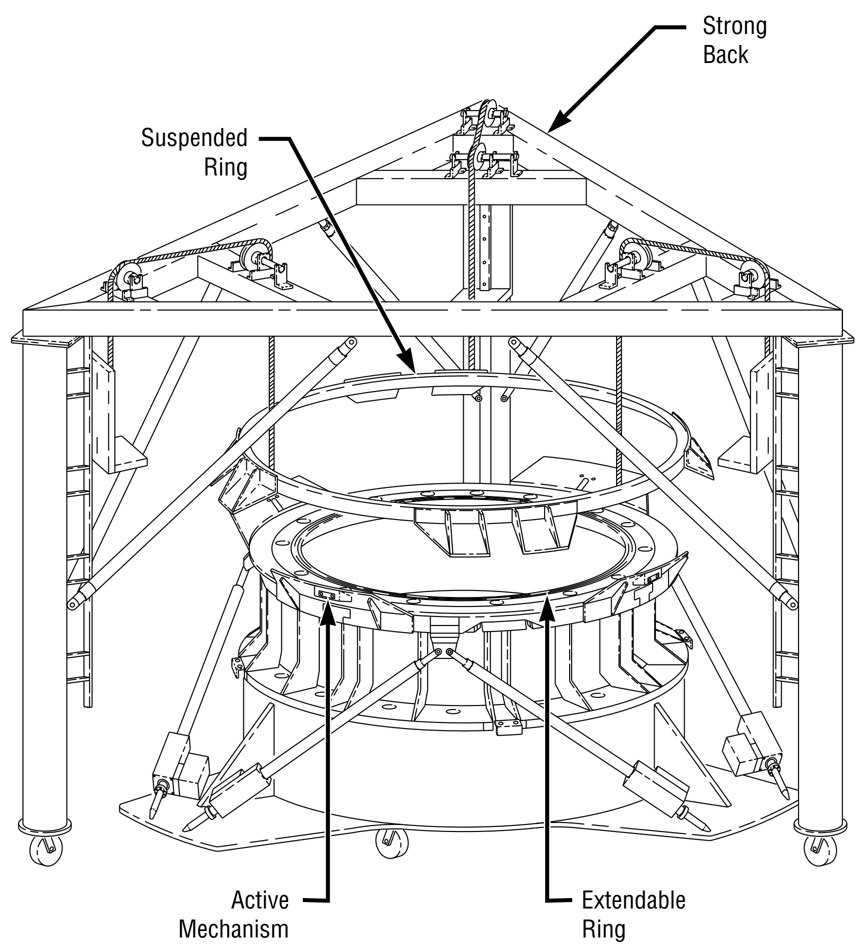

FIGURE 42.—Active docking mechanism.

The proposed effort seeks to take one of the current docking system designs, the Space Station Phase B docking/berthing system, and modifying it to develop a capture-berthing system and then characterize the systems performance. The present design of the space station Phase B docking/berthing system lends itself well to the application of capture-berthing. The system was developed in a joint program between MSFC and McDonnell Douglas Aerospace during the Phase B phase of the *Space Station Freedom* program.

Work has begun on the project. Figure 42 shows the hardware setup. The active mechanism represents the chase spacecraft and the suspended ring represents the target spacecraft. The active mechanism has an extendible ring which is attached by six linear actuators. These actuators, through the use of a control program, position the centroid of the extendible ring on the centroid of the suspended ring, thus enabling the capture-berth. The actuators then damp the motion of the suspended ring and pull the captured ring down to be mated with the active mechanism. The target centroid location is obtained through the use of a video guidance sensor which has been developed by MSFC and this 6-degrees-of-freedom target data is used by the control program to determine the positioning of the extendible ring. The control program was developed utilizing Labview, an icon driven, graphical, data acquisition and control program in conjunction with Motion Toolbox, an application used to control the actuators. The control program uses the target location and the geometry of the active mechanism to determine the required lengths of the six actuators to bring the two centroids together. The test stand provides 5-degrees-of-freedom motion, excluding roll, to the suspended ring to simulate the relative motion of two spacecraft in close proximity.

In developing and proving the new technology, the proposed activity seeks to lay the groundwork for the next generation of spacecraft mating hardware. The new approach, capture-berthing, combines many of the strengths of previous systems while avoiding many of their problems and thereby enabling many different spacecraft to be mated on orbit.

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Biographical Sketch: Alan Bean has worked with mechanism design since April 1990 in the MSFC Propulsion Laboratory. Bean obtained his spacecraft mating expertise during his work as a design engineer for the *Space Station Freedom* common berthing mechanism. Bean has also been involved in the development of advanced proximity sensors which are used for spacecraft mating.